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# **Spatial Patterns of Sanitation in Rural Vietnam: An Application of Small Area Estimation**

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10 February 2017

Online at <https://mpa.ub.uni-muenchen.de/85704/>

MPRA Paper No. 85704, posted 5 April 2018 09:52 UTC

# **Spatial Patterns of Sanitation in Rural Vietnam: An Application of Small Area Estimation**

**Nguyen Viet Cuong**

## **Abstract**

Diarrhea is one of the main causes for mortality of under-five children (Boschi-Pinto et al., 2008), and this disease can be attributed to deficient hygiene, sanitation and water supply (Bartram and Cairncross, 2010). Information on spatial patterns of sanitation is very important for sanitation support programs. In this study, we estimate and construct spatial maps of the proportion of households using sanitary latrines in rural Vietnam using a small area estimation method. It shows that there is a great spatial variation in the sanitary latrine rate. Within the same rural districts, the proportion of households using sanitary latrines varies largely across communes.

**Keywords:** Sanitary latrine, poverty mapping, small area estimation, Vietnam.

## 1. Introduction

Although, the worldwide under-five child mortality rate dropped significantly over time, the mortality was still estimated at 43 deaths per thousand live births per year in 2015 (The Inter-agency Group for Child Mortality Estimation, 2015). Global deaths from diarrhea of under-five children were estimated to account for 19% of total child deaths (Boschi-Pinto et al., 2008) and this massive disease burden is attributed to deficient hygiene, sanitation and water supply (Bartram and Cairncross, 2010). Yet, there are still a large proportion of people who do not have access to it. According to an estimate from World Bank (2015), 33% of the world population did not have access to improved latrines in 2015. Most countries have implemented programs to promote the access to hygienic or sanitary latrines.

An important question in all targeted programs is how to identify beneficiaries. More detailed information on beneficiaries increases the effectiveness of targeted programs (e.g. Bigman and Fofack (2000) and Elbers *et al.* (2007). Information on sanitary latrines is available in most household surveys, but household surveys are sampled and not representative at small areas. On the other hand, population censuses cover the whole population but most of them do not contain data on sanitary latrines. Elbers et al. (2002, 2003) develop a small area estimation method to combine a household survey and a population census in order to estimate poverty and inequality at small areas.<sup>1</sup>

In this study, we will combine the 2011 Rural Agriculture and Fishery Census (RAFC) and the 2011 Viet Nam Multiple Indicator Cluster Survey (MICS) to estimate the sanitary latrine rate at small areas including districts and communes using the method of Elbers et al. (2002, 2003). Vietnam is a country with great success in poverty reduction. However, around 42.8% of households do not have access to sanitary latrines (according to the 2011 MICS). The proportion of households without sanitary latrine is much higher in rural households, at 56.5%, and ethnic minorities, at 76.6%.

There is a great geographical variation in living standards in Vietnam. Households who are living in delta are much better off than households in regions of Northern Mountain and Central Highlands. Access to sanitary latrines can also vary substantially across geographical areas. To provide supports on sanitary latrines, it is very important to have information on households' access to sanitary latrines at small areas such as districts and communes. Vietnam has a large number of large-scale household surveys and censuses.

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<sup>1</sup> In Vietnam, this method is applied to estimate the poverty and inequality at small areas in e.g., Minot *et al.* (2003), Nguyen (2012), Lanjouw et al. (2017), and Bui and Nguyen (2017). The method has been applied in around 40 countries in the world to predict the poverty (Bedi et al. 2007).

Yet, most surveys and censuses do not have detailed information on latrine types. Possibly, only the Viet Nam Multiple Indicator Cluster Surveys (MICS) are large-scale and nationally representative surveys which contain detailed information on latrines to define sanitary latrines according to MOH's definition. Although the 2011 MICS contains data on sanitary latrines, it does not have a large sample to generate the estimates at the small areas such as communes and districts. In this study, using the method of Elbers et al. (2002, 2003) we will combine the 2011 MICS with the 2011 RAFC to estimate the proportion of households with sanitary latrines at the commune, district and province levels.

The remaining of the report is structured into 3 sections. Section 2 presents the data sets used in this study. Sections 3 and 4 present the estimation method and empirical results, respectively. Finally section 5 concludes.

## **2. Data set**

This study will rely on two data sets. The first data set is the Rural Agriculture and Fishery Census (RAFC) in 2011. The RAFC were carried out by the GSO in July 2011. The censuses covered all households in rural areas. The censuses contain data on individuals and households including basic demography, employment and housing, and agricultural activities. There are also commune-level data on socio-economic conditions, agricultural production, infrastructure and transportation, education, health, and social affairs of all the rural communes throughout the country. There are 16,194,218 households covered in the census. More information on the 2011 RAFC can be found in MPI (2011).

The Viet Nam Multiple Indicator Cluster Survey (MICS 2011) was conducted from December 2010 to January 2011 by the General Statistics Office of Viet Nam (GSO) with financial and technical support from United Nations Children's Fund (UNICEF) and the United Nations Population Fund (UNFPA) in Viet Nam. MICS 2011 contains detailed data on characteristics of children and women in Viet Nam. The 2011 MICS also contains data on household living standard including assets, durables, and housing conditions. The survey is representative at the urban/rural areas and regions. The number of households sampled in the 2011 MICS is 11,617 households. In this study, we use the rural sample, which covered 6,507 households (GSO, 2011).

The 2011 MICS contains data on types of latrine used by households. Table 1 presents the latrine type in the 2011 MICS for the full sampled and rural sampled households (without sampling weight). Based on the MOH's definition, sanitary latrines include four types: Flush to piped sewer system; Flush to septic tank; Flush to pit (latrine); Ventilated Improved Pit latrine (VIP) (the first four latrine types in Table 1). When

sampling weight is applied, the proportion of households with sanitary latrines in rural areas is 43.46%.

Table 1: Type of latrine in the 2011 MICS

Type of toilet facility	Code in MICS	All sample		Rural sample	
		Observations	Percent	Observations	Percent
<i>Sanitary latrines</i>					
Flush to piped sewer system	11	204	1.68	52	0.8
Flush to septic tank	12	6,308	51.3	2,334	36
Flush to pit (latrine)	13	519	3.78	331	5.09
Ventilated Improved Pit latrine (VIP)	21	56	0.49	26	0.4
<i>Other latrines</i>					
Flush to somewhere else	14	58	0.48	32	0.49
Flush to unknown place / Not sure / DK	15	25	0.22	9	0.14
Pit latrine with slab	22	1,045	9.73	848	13
Pit latrine without slab / Open pit	23	545	4.13	461	7.08
Composting toilet	31	1,069	11.94	911	14
Bucket	41	16	0.12	8	0.12
Hanging toilet, Hanging latrine	51	885	9.78	713	10.96
No facility, Bush, Field	95	837	5.96	745	11.45
Other	96	43	0.37	35	0.54
Missing	99	4	0.02	2	0.03
<b>Total</b>		<b>11,614</b>	<b>100</b>	<b>6,507</b>	<b>100</b>

### 3. Estimation method

The Elbers et al. (2002, 2003) method can be described by three steps as follows. In the first step, we select common variables of the 2011 RAFC and the 2011 MICS. The common variables include household composition, land, water and housing conditions, and durables. Commune variables that are computed from the 2011 RAFC are also merged to the 2011 MICS. For example, we can calculate the average crop size at the commune level from the 2011 MICS and include this variable in the 2011 MICS to estimate the model of sanitary latrine.

In the second step, we regress the sanitary latrine on the selected common variables using data from the 2011 MICS. More specifically, we estimate the following model:

$$Y_{ic} = \alpha + X_{ic}\beta + \varepsilon_{ic}, \quad (1)$$

where  $Y_{ic}$  is a dummy variable indicting whether household  $i$  in cluster  $c$  has access to a sanitary latrine,  $X_{ic}$  the vector of the common variables,  $\alpha$  and  $\beta$  are regression coefficients,  $\varepsilon_{ic}$  is error terms. The subscript  $ic$  refers household  $i$  living in cluster  $c$ . The sanitary latrine is defined according to the definition of MOH (see Table 1).

In the third step, we use the predicted model to estimate the access to sanitary latrine for households in the 2011 RAFC:

$$\hat{Y}_{ic} = \hat{\alpha} + X_{ic}^{Census} \hat{\beta} + \hat{\varepsilon}_{ic}, \quad (2)$$

where  $\hat{\alpha}$ ,  $\hat{\beta}$  and  $\hat{\varepsilon}_{ic}$  denote the estimates for  $\alpha$ , and  $\beta$ , and  $\varepsilon_{ic}$ . The predicted  $\hat{Y}_{ic}$  are used to compute the proportion of households having access to sanitary latrines at the commune, district and provincial levels. The point estimates as well as the standard errors of the satisfaction level are calculated by Monte-Carlo simulations. In each simulation, a set of values  $\hat{\alpha}$ ,  $\hat{\beta}$ , and  $\hat{\varepsilon}_{ic}$  are drawn from their estimated distributions, and an estimate of the proportion of households having access to sanitary latrines at the commune, district and provincial level are obtained. After  $k$  simulations, we can get the average and standard deviation over the  $k$  different simulated values of the proportion of households having access to sanitary latrines.

It should be noted that there is a question on whether households used a flush latrine in the 2011 RAFC. However, there is no information on other types of latrines. A flush latrine is considered as a sanitary latrine. It means that we only need to estimate the probability of having a sanitary latrine for households without a flush latrine. If we estimate the sanitary latrine model for households without a flush latrine, it can lead to the selection bias. Thus, we employ the idea of switching models: instead of estimating model (1), we will estimate the following model:

$$Y_{ic} = Z + (1 - Z)(\alpha + X_{ic}\beta + \varepsilon_{ic}), \quad (3)$$

where  $Z$  is a dummy variable indicating whether a household has flush toilet. If a household has a flush toilet ( $Z$  equals 1), then the household's latrine is defined as a sanitary latrine, and variable  $Y$  equals one. If a household does not a flush toilet ( $Z$  equals zero), then model

(3) will be used to estimate the probability of having a sanitary latrine. Equation (3) can be expressed as follows:

$$Y_{ic} = \alpha + (1 - \alpha)Z + (ZX_{ic} - X_{ic})\beta + (1 - Z)\varepsilon_{ic}, \quad (4)$$

In this study, we will estimate model (4) using the 2011 MICS and apply the estimated model to the 2011 RAFC to predict the proportion of households with a sanitary latrine at the commune and district level.

#### 4. Estimation results

Tables A.1 to A.6 present the estimation of models of sanitary latrine. Each model is estimated for each region. Table 2 compares the regional estimates based directly on data from the 2011 MICS and those from the small area estimation. Both estimates are quite close. It provides an evidence of the reliable estimates from the small area estimation method. The estimates from the small area estimation have smaller standard errors than those based on MICS. By regions, Northern Mountains has the lowest proportion of sanitary latrines, while South East has the highest proportion of sanitary latrines.

Table 2: The proportion of households having sanitary latrines by regions (in percent)

Regions	Number of households	% households with sanitary latrine: estimate from the 2011 MICS		% households with sanitary latrine: estimate from the small area estimation method	
		Estimate	Standard error	Estimate	Standard error
Northern Mountain	2224291	22.25	2.87	20.22	0.72
Red River Delta	3842133	58.04	3.32	60.10	0.87
Central Coast	3656308	40.45	4.09	37.89	1.62
Central Highland	862680	39.61	4.08	38.13	1.72
South East	1429570	79.95	3.27	77.12	2.71
Mekong River Delta	3324644	34.87	3.44	31.44	2.12

*Source: estimation from the 2011 RAFC and the 2011 MICS*

Table 3 presents the proportion of sanitary latrines by provinces. Rural households Cao Bang and Tuyen Quang are those with the lowest access to sanitary latrines. Da Nang is the city with the highest proportion of households with access to sanitary latrines, followed by Ho Chi Minh city, Dong Nai anh Binh Duong.

Table 3: The proportion of households having sanitary latrines by provinces (in percent)

Province code	Province name	Number of households	% households with sanitary latrine	Std. Err.
<b><i>Northern Mountain</i></b>				
2	Ha Giang	127363	15.49	1.58
4	Cao Bang	89801	13.15	1.63
6	Bac Kan	58838	18.27	1.60
8	Tuyen Quang	158733	13.74	3.74
10	Lao Cai	103252	19.55	1.75
11	Dien Bien	86069	18.70	2.22
12	Lai Chau	62270	16.31	1.95
14	Son La	201982	17.55	1.40
15	Yen Bai	145824	19.53	1.95
17	Hoa Binh	162112	20.24	1.53
19	Thai Nguyen	223755	28.13	1.74
20	Lang Son	137758	16.82	1.47
24	Bac Giang	374004	23.55	1.54
25	Phu Tho	292530	23.31	1.52
<b><i>Red River Delta</i></b>				
1	Ha Noi	942634	73.82	1.49
22	Quang Ninh	139108	43.63	2.02
26	Vinh Phuc	198603	44.23	2.25
27	Bac Ninh	219062	67.44	2.08
30	Hai Duong	401853	53.93	1.58
31	Hai Phong	282746	59.84	2.19
33	Hung Yen	283615	62.27	1.76
34	Thai Binh	498287	48.14	1.93
35	Ha Nam	209631	52.30	2.39
36	Nam Dinh	456356	62.33	2.15
37	Ninh Binh	210238	57.43	2.81
<b><i>Central Coast</i></b>				
38	Thanh Hoa	783353	28.32	2.30
40	Nghe An	633822	26.92	2.88
42	Ha Tinh	295151	27.29	3.36
44	Quang Binh	181165	40.20	3.98
45	Quang Tri	107850	49.02	3.62
46	Thua Thien Hue	149660	36.53	8.95
48	Da Nang	30171	89.40	9.08
49	Quang Nam	308088	52.12	3.30
51	Quang Ngai	277009	51.06	3.42
52	Binh Dinh	291273	39.64	3.83
54	Phu Yen	180237	36.59	3.73
56	Khanh Hoa	158246	55.63	4.15
58	Ninh Thuan	87972	48.38	4.79
60	Binh Thuan	172311	52.85	4.25



Province code	Province name	Number of households	% households with sanitary latrine	Std. Err.
<b><i>Central Highlands</i></b>				
62	Kon Tum	67045	30.62	3.22
64	Gia Lai	209361	31.15	2.08
66	Dak Lak	304636	31.79	2.71
67	Dak Nong	100064	42.71	4.77
68	Lâm Dong	181574	57.05	2.88
<b><i>South East</i></b>				
70	Binh Phuoc	173669	59.62	5.31
72	Tay Ninh	239905	64.62	4.04
74	Binh Duong	148101	82.91	4.43
75	Dong Nai	424673	83.87	4.07
77	Ba Ria - Vung Tau	121408	77.57	4.13
79	Ho Chi Minh	321814	84.15	4.75
<b><i>Mekong River Delta</i></b>				
80	Long An	307526	50.26	4.85
82	Tien Giang	384317	45.71	5.21
83	Ben Tre	331119	38.29	4.52
84	Tra Vinh	217029	12.14	5.58
86	Vinh Long	229586	35.37	5.65
87	Dong Thap	346949	31.46	5.01
89	An Giang	365317	39.38	5.88
91	Kiên Giang	292869	17.43	4.96
92	Can Tho	96727	33.34	6.19
93	Hau Giang	140221	22.03	5.78
94	Soc Trang	247787	15.71	4.82
95	Bac Lieu	145502	19.9	5.08
96	Ca Mau	219695	20.83	5.62

Finally, Figures 1 to 3 present the proportion of rural households with access to sanitary latrines at the province, district and commune level. Provinces in Northern Mountains have very low rates of sanitary latrines. In Mekong River Delta, several provinces such as Kien Giang, Tra Vinh, Bac Lieu and Soc Trang also have low sanitary latrine rates. Figure 2 shows that within a province (the province borders are presented by solid line), there is variation in the hygienic latrines across districts. In some provinces in Central Highlands with middle rates of sanitary latrine, there are districts with very low sanitary latrine rates (below 10%). Similarly, there is a large variation in the percentage of sanitary latrines across communes in the same districts (Figure 3).

Figure 1: The proportion of households with sanitary latrines by provinces

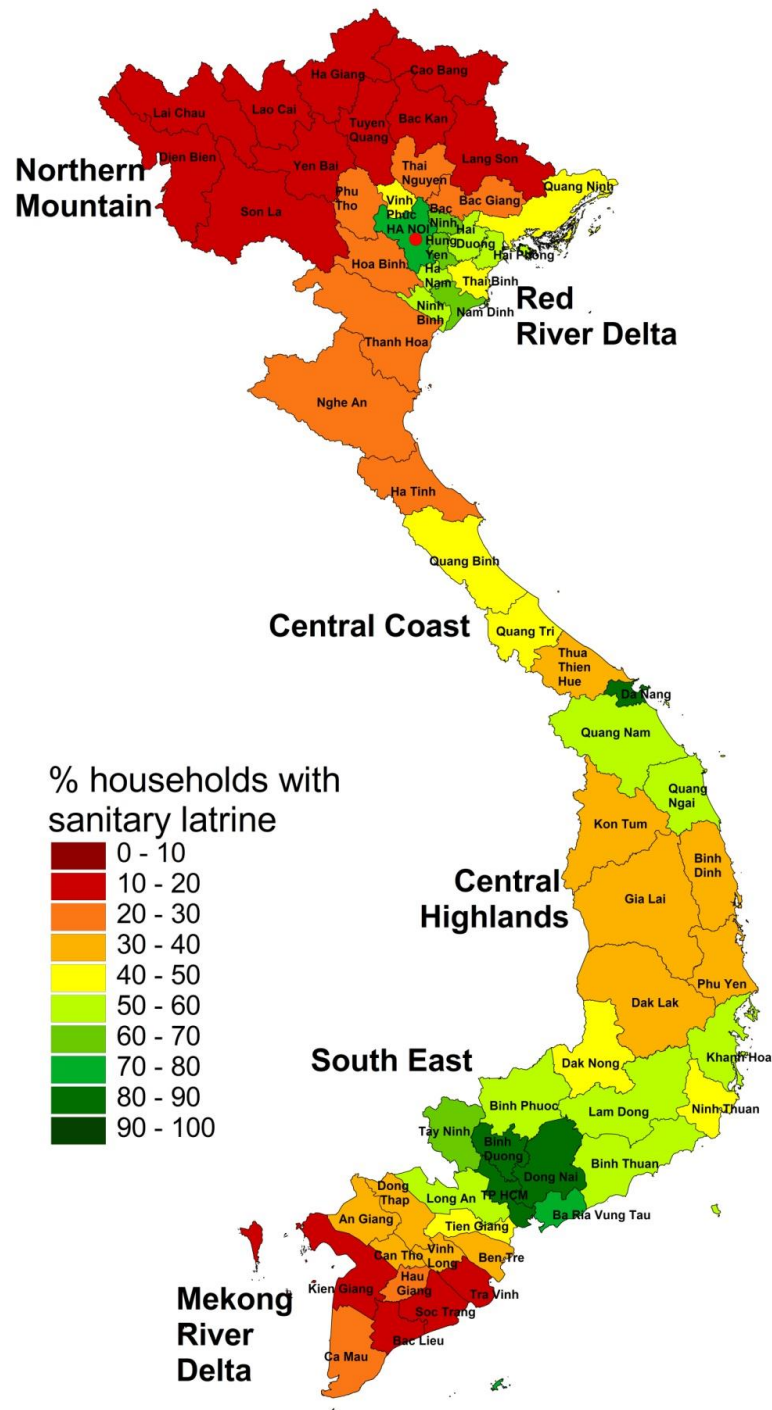
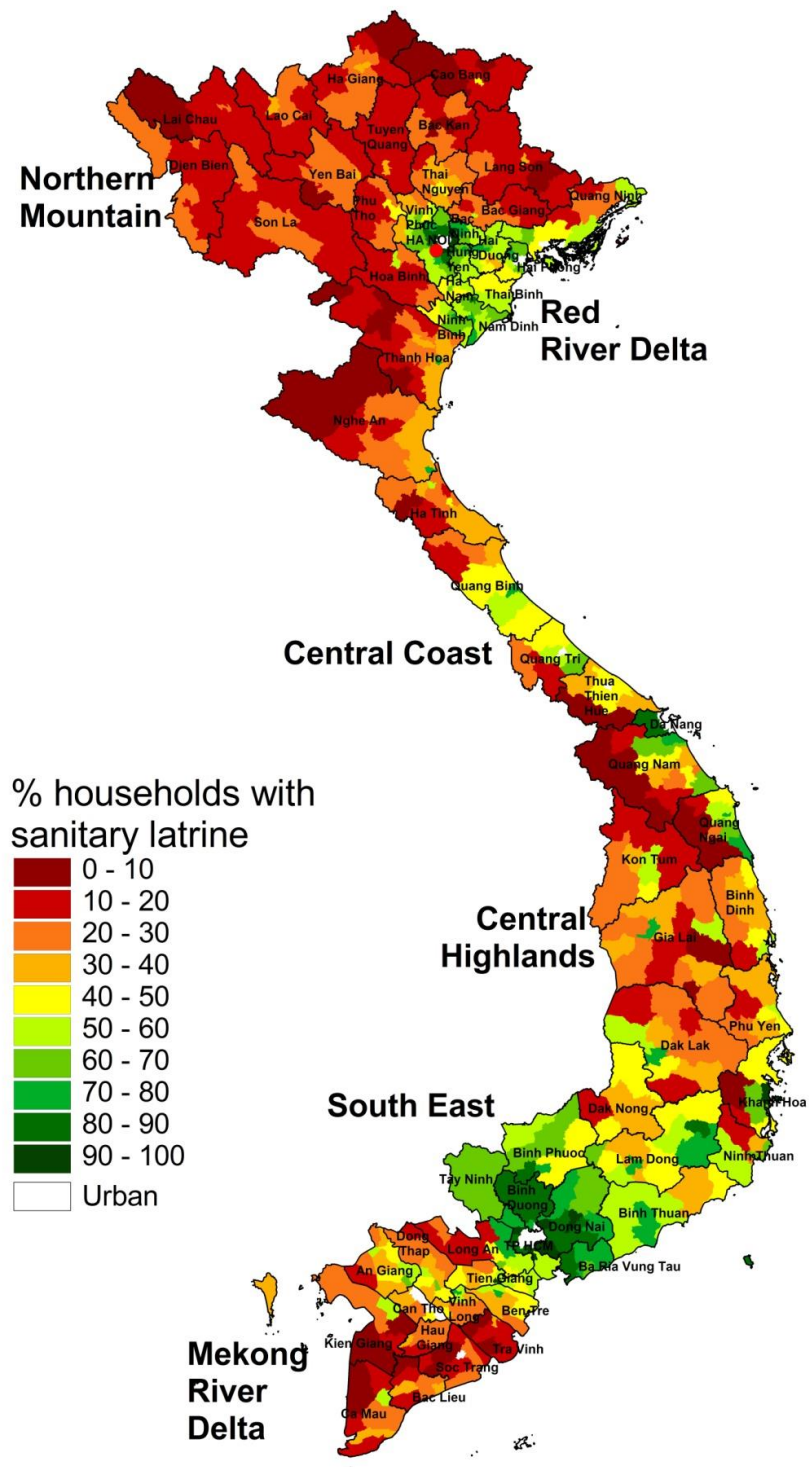


Figure 2: The proportion of households with sanitary latrines by districts



**Northern Mountain**

**Red River Delta**

**Central Coast**

**Central Highlands**

**South East**

**Mekong River Delta**

% households with sanitary latrine

- 0 - 10
- 10 - 20
- 20 - 30
- 30 - 40
- 40 - 50
- 50 - 60
- 60 - 70
- 70 - 80
- 80 - 90
- 90 - 100
- Urban

## **5. Conclusion**

Vietnam is a country which have been successfully in poverty reduction. However, there is still a large proportion of households who do not access to sanitary latrines, especially in rural areas. To provide sanitation support programs, it is very important to have more detailed information on location of households who lack the access to sanitary latrines. In this study, I combine the 2011 Rural Agriculture and Fishery Census (RAFC) and the 2011 Viet Nam Multiple Indicator Cluster Survey (MICS) to estimate the sanitary latrine rate at small areas including districts and communes in rural Vietnam.

The results show a strong spatial variation in the sanitary latrine rate in Vietnam. Most provinces in Northern Mountain region have very low rates of sanitary latrines. This region is also the poorest one in Vietnam. Although Mekong River Delta has higher income than Central Highlands, it has a lower proportion of households using sanitary latrines than Central Highlands. It implies that information on not only monetary poverty but also nonmonetary dimensions such as sanitation is important for poverty targeting. In addition, sanitation data at more disaggregated areas is more informative for targeting of the support programs. In some provinces with middle rates of sanitary latrine, there are districts and communes with a very low sanitary latrine rate.

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## Appendix

Table A.1. Regression of sanitary latrine in North Mountain

Explanatory variables	Coefficient	Std. Err.	t	Prob >t
_intercept_	0.1942	0.0757	2.5638	0.0105
Commune proportion of households having buffalo	0.1841	0.0588	3.1297	0.0018
Commune proportion of households having chicken	-0.3120	0.0878	-3.5544	0.0004
Household having Household having computer	0.3654	0.0452	8.0825	0.0000
Commune proportion of households having computer	2.3034	0.4546	5.0674	0.0000
Household having Household having fridge	0.2022	0.0246	8.2196	0.0000
Number of high schools in commune	0.0842	0.0296	2.8433	0.0045
Commune having market	0.0722	0.0239	3.0282	0.0025
Household having mobile phone	0.0601	0.0262	2.2964	0.0218
Commune proportion of people working in service sector	-1.1562	0.4266	-2.7100	0.0068
Tuyen Quang province	-0.1140	0.0394	-2.8938	0.0039
Household having piped water	0.2277	0.0537	4.2418	0.0000
R-squared	0.2977			
Number of observations	1155			
Rho	0.015			

Source: estimation from the 2011 RAFC and the 2011 MICS

Table A.2. Regression of sanitary latrine in Red River Delta

Explanatory variables	Coefficient	Std. Err.	t	Prob >t
_intercept_	-0.3900	0.1631	-2.3907	0.0170
Household having buffalo and cows	-0.1239	0.0483	-2.5638	0.0105
Household having chicken	-0.0795	0.0266	-2.9880	0.0029
Household having computer	0.1200	0.0413	2.9035	0.0038
Commune proportion of households having computer	-0.9949	0.3118	-3.1907	0.0015
Commune proportion of households having clean (not-piped) water	0.1122	0.0485	2.3127	0.0209
Household having fridge	0.2629	0.0286	9.1831	0.0000
Number of high schools in commune	0.0598	0.0261	2.2965	0.0218
Commune proportion of households having livestock	-0.4471	0.1032	-4.3311	0.0000
Household having mobile phone	0.1352	0.0332	4.0698	0.0001
Commune proportion of households having motorbike	1.0363	0.1813	5.7173	0.0000
Household having desk telephone	0.0743	0.0271	2.7420	0.0062
Commune proportion of households having desk telephone	0.6848	0.1406	4.8717	0.0000
Nam Dinh province	0.1488	0.0416	3.5783	0.0004
Ninh Binh province	0.2161	0.0578	3.7383	0.0002
Household having unclean water	-0.1086	0.0269	-4.0338	0.0001
R-squared	0.294			
Number of observations	1161			



Rho

0.011

*Source: estimation from the 2011 RAFC and the 2011 MICS*

Table A.3. Regression of sanitary latrine in Central Coast

Explanatory variables	Coefficient	Std. Err.	t	Prob >t
_intercept_	-0.7523	0.1225	-6.1415	0.0000
Household having buffalo and cows	-0.1783	0.0265	-6.7255	0.0000
Household having television	0.1127	0.0408	2.7635	0.0058
Household having computer	0.1848	0.0449	4.1205	0.0000
Commune proportion of households having flush latrine	0.8591	0.0757	11.3532	0.0000
Household having fridge	0.1863	0.0301	6.1965	0.0000
Commune having irrigation system	0.1020	0.0345	2.9617	0.0031
Commune proportion of Kinh households	0.2159	0.0700	3.0837	0.0021
Household having mobile phone	0.1340	0.0275	4.8687	0.0000
Commune proportion of agricultural workers	0.3324	0.0964	3.4489	0.0006
Commune having secondary school	0.2315	0.0458	5.0522	0.0000
Household having desk telephone	0.1191	0.0246	4.8389	0.0000
Thua Thien Hue city	-0.2798	0.0768	-3.6438	0.0003
Commune having water program	0.0794	0.0347	2.2873	0.0224
R-squared	0.386			
Number of observations	1160			
Rho	0.055			

*Source: estimation from the 2011 RAFC and the 2011 MICS*

Table A.4. Regression of sanitary latrine in Central Highland

Explanatory variables	Coefficient	Std. Err.	t	Prob >t
_intercept_	0.4187	0.2415	1.7335	0.0833
Household having Household having computer	0.1656	0.0428	3.8725	0.0001
Commune proportion of households having crop	-0.5902	0.2406	-2.4529	0.0143
Commune having cultural house	0.1428	0.0271	5.2624	0.0000
Household having Household having fridge	0.2254	0.0293	7.7014	0.0000
Commune proportion of households with garbage place	1.3668	0.1699	8.0463	0.0000
Commune having kindergarten	0.0987	0.0152	6.5061	0.0000
Household is Kinh majority	0.1924	0.0279	6.8841	0.0000
Household having mobile phone	0.1591	0.0326	4.8868	0.0000
Number of lenders in commune	-0.2198	0.0575	-3.8205	0.0001
Proportion of lands with certificate in commune	0.0027	0.0006	4.5029	0.0000
Road village in communes	-0.0225	0.0027	-8.2022	0.0000
Dak Nong province	0.1132	0.0430	2.6314	0.0086
R-squared	0.3678			
Number of observations	1168			
Rho	0.036			

Source: estimation from the 2011 RAFC and the 2011 MICS

Table A.5. Regression of sanitary latrine in South East

Explanatory variables	Coefficient	Std. Err.	t	Prob >t
_intercept_	-0.5373	0.3917	-1.3716	0.1706
Commune proportion of households having buffalo	-0.9426	0.5034	-1.8725	0.0615
Commune proportion of households with electricity	0.8852	0.4163	2.1263	0.0338
Household having electric fan	0.1958	0.0932	2.1011	0.0360
Household having fridge	0.2039	0.0292	6.9743	0.0000
Commune proportion of households using gas for cooking	0.2404	0.0920	2.6128	0.0092
Commune having irrigation system	-0.0981	0.0297	-3.3037	0.0010
Household having mobile phone	0.0854	0.0445	1.9199	0.0553
Commune proportion of households receiving microcredit	-0.0035	0.0011	-3.2964	0.0010
Household having desk telephone	0.0565	0.0285	1.9864	0.0474
Dong Nai province	0.0844	0.0312	2.7053	0.0070
R-squared	0.2529			
Number of observations	771			
Rho	0.016			

Source: estimation from the 2011 RAFC and the 2011 MICS

Table A.6. Regression of sanitary latrine in Mekong River Delta

Explanatory variables	Coefficient	Std. Err.	t	Prob >t
_intercept_	-0.2760	0.0581	-4.7496	0.0000
Commune proportion of households having bathroom	0.4003	0.0839	4.7686	0.0000
Household having computer	0.2526	0.0476	5.3051	0.0000
Commune proportion of households having flush latrine	0.8578	0.1255	6.8366	0.0000
Commune proportion of households having clean (not-piped) water	0.2307	0.0346	6.6604	0.0000
Household having electric fan	0.1247	0.0360	3.4674	0.0005
Household having fridge	0.2685	0.0280	9.5769	0.0000
Household size	-0.0193	0.0074	-2.5964	0.0095
Household having desk telephone	0.0615	0.0255	2.4099	0.0161
Household having clean water (non-piped)	-0.1015	0.0248	-4.0928	0.0000
R-squared	0.3196			
Number of observations	1152			
Rho	0.085			

Source: estimation from the 2011 RAFC and the 2011 MICS

